trast in color between the tissues of the two species enables one to follow in the living specimen the exact development of each part. If the tail-bud of an embryo (ca. 4.5 mm. long) of one species be replaced by a similar portion taken from the other, it may be observed that, as the tail grows, the epidermis from the body moves out over the base of the tail until about the end of the sixth day it covers its proximal two-thirds. The underlying tissues (muscle plates, notochord and spinal cord) grow apically, and the place of union between the two portions remains very near to the base of the tail, although it does shift with respect to the anus through a distance equal to about three metameres. When several segments of the body are grafted along with the tail, a similar shifting of the epidermis takes place, though less in amount, and even when the two parts are united in the region of the pronephros there is a slight backward movement. This is brought about largely, if not entirely, by the pulling of the skin due to the enormous growth of the tail as compared with the body. The parallel between the direction and amount of movement of the epidermis during development,and the mode of distribution of the cutaneous nerves in the body and tail of full-grown tadpoles, indicates that each nerve supplies that region of the integument which, at an early stage, was nearest to it.

When, in place of a tail-bud which has been removed, a similar portion of another larva is grafted by its distal end, leaving the proximal end free, a tail-like structure is regenerated. In cases where the notochords of the two parts unite, the regenerated tail attains a degree of perfection but little inferior to those regenerated from the distal end. If the notochords do not unite, regeneration may take place from both pieces, resulting in a forked tail. When neither the notochords nor spinal cords unite, the tail stump of the stock regenerates, while the grafted piece remains as an insignificant lump on the side of the tail.

In all cases (six) where virescens tails were grafted to palustris larvæ, and in fifty per cent. (four) of the cases in which palustris were grafted to virescens larvæ, degeneration of the transplanted tissue took place, beginning sometimes as early as three weeks after operation. This was independent of metamorphosis, having begun before the appearance of the extremities. The tadpoles lived for weeks afterwards with withered tails, without undergoing further metamorphosis.

One specimen in which the two parts were united in the region of the pronephros passed successfully through its metamorphosis. Little or no blending of specific characters could be observed. The head of the frog had the markings of *R. virescens*, while the body and hind legs had those of *R. palustris*.

The Structure and Development of the Excretory Organs in Limulus. W. PATTEN.

THE brick-red gland or coxal gland of *Limulus* has long been regarded as a ductless gland of uncertain significance, but we are now able to demonstrate that it is provided with a duct several millimeters in diameter and three or four inches long.

Its development has also been carefully studied, but the structure described as the developing gland proves to be the developing duct; the embryonic gland was not seen at all.

Naturally, the conclusions as to the significance of this organ based on such foundations can have but little value.

The duct in the adult is so thin-walled that it is not readily seen and is very difficult to dissect. But it may be easily injected with either celloidin or asphalt, the mass filling the duct and penetrating all through the lobes of the gland. Isolation is then effected by corrosion with caustic potash.

The duct runs straight forward along the dorso-lateral margin of the plastron, then back again, and, after many coilings, opens into a large irregular chamber, or end-sac, a remnant of the fifth coelomic cavity, situated in the middle of the posterior nephric lobe. The embryonic nephric duct develops as a tubular outgrowth of the ventral wall of this cavity. Its distal end finally unites with a short ectodermic ingrowth (readily distinguished in the adult), which opens at the base of the fifth leg.

The secretions from the four lobes of the gland are collected by gradually widening anastomosing tubules. Each lobe has many separate openings into the large tubules of the longitudinal stolon. The latter empty into the coelomic space, or end-sac, and from there a single nephric duct carries the secretions to the external opening at the base of the fifth leg.

The glandular portion of the kidney develops from six pairs of segmentally arranged 'anlagen.' Omitting all details, it may be stated that a part of the fifth coelomic cavity persists as the thin-walled chamber, or end-sac, mentioned above.

The other cavities of the thorax break down after producing, by a thickening of their neural walls, paired masses of finely granular cells. These cells become hollow and unite end to end to form irregular groups of anastomosing tubules. The longitudinal tubules of the stolon are formed in a similar manner by the union of outgrowths from each cluster of cells. Many tubes on the periphery of the gland retain this unicellular condition in the adult, but in the center of the lobes and in the longitudinal stolon the nuclei of the tubules have multiplied rapidly, giving rise to a lining endothelium of flattened cells.

The cell masses derived from the walls of the first and sixth coelomic cavities disappear. The remaining ones form the four lobes of the adult kidney.

The kidney of *Limulus* is, therefore, derived from segmentally arranged groups of excretory cells. Each group of cells probably emptied originally into its corresponding coelomic cavity, and from there to the exterior. These separate external openings have now disappeared, and the organs are united by longitudinal tubules which open by a single duct, or coelomic funnel, to the exterior.

I consider the kidney, the nephric duct and the genital duct of *Limulus* homologous, respectively, with the pronephros, the pronephric duct and the Müllerian duct of Vertebrates.

Many of the details of the above account were worked out in the biological laboratory at Dartmouth by Miss Annah P. Hazen. They will be fully described and illustrated in a joint paper that we hope will appear at an early date in the *Journal of Morphology.*

The Reaction of Amœba to Light of Different Colors and to Röntgen Rays. N. R. HARRINGTON and EDWARD LEAMING.

THE physiological effect of Röntgen rays upon undifferentiated protoplasm is almost imperceptible as compared with the reaction produced by mechanical stimuli, heat, electricity or light.

We have found that *Amœba proteus* is extremely sensitive to changes in the color of light in which it is placed, and that it exhibits characteristic movements in different light environments.

The remarkably delicate condition of phototonus is, we think, dependent upon a favorable quality of light and an optimum temperature. Continuance in a given color produces a more or less characteristic flow ; in violet a spasmodic, unsuccessful attempt to form pseudopods; in green or red a massive, diffuse bodily flow.

A quiescent *Amœba* brought from the room light into red light begins to flow in from ten to twenty-five seconds. The flow